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Policy measures to overcome barriers to energy renovation of existing buildings

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ABSTRACT

Even though there is great potential to reduce greenhouse gas emissions from existing buildings, most political effort in Korea has been focused on the construction of new buildings; few concrete measures have been taken to limit greenhouse gas emissions from existing buildings. This study examined the potential to reduce greenhouse gas emissions from existing residential buildings as a means to cope with global warming. Additionally, several barriers to improving the energy performance of existing dwellings instead of constructing new dwellings were explored. The major barriers to improving the energy performance of existing residential buildings are: (1) a lack of awareness; (2) financial reasons; (3) insufficient information; and (4) the absence of regulatory systems. To overcome such barriers, systems adopted and implemented in developed European countries were considered and their feasibility was verified so that political measures could be suggested to improve the energy performance of existing dwellings in Korea.

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1. Introduction

1.1. Background and objective of research

The building sector is responsible for more than 40% of the world's resource and energy consumption and approximately 33% of the total carbon dioxide (CO_2) emissions [1–3]. It also represents a major target for improvement and is generally addressed by most environmental policies. Korea has taken many political measures focused on the building sector with the aim of reducing CO_2 emissions by 26.9% compared to the business as usual (BAU) scenario by 2010. Even though there is great potential for reducing the greenhouse gas emissions from existing buildings [4,5], most political effort in Korea has focused on the construction of new buildings, and few measures have been taken to limit greenhouse gas emissions from existing buildings. Construction-oriented policies in a national strategy to reduce greenhouse gas emission are limited; to achieve the goal of reducing greenhouse gas emissions caused by the building sector, existing buildings must be considered.

Since the 1990s, several developed European countries have implemented various measures to improve the energy efficiency of buildings, which are responsible for a large share of the total greenhouse gas emissions. Policies for newly constructed buildings occupied a significant position in the 1990s, but in the 2000s, policy targets have shifted towards improving the energy performance of existing buildings. For example, in the OECD/IEA Joint Workshop on Sustainable Buildings held in June 2000, the participating nations reached a consensus on the importance of the existing housing stock [6]; in addition, the European Ministers Conference on Sustainable Housing held in 2002 promoted the establishment of systems for existing dwellings [7,8].

Therefore, the objective of this study was to review the policies in the developed European nations towards the energy efficiency of existing buildings and to present political measures for improving the energy performance of existing buildings in Korea.

1.2. Subjects and methods of research

In this study, the potential to reduce greenhouse gas emissions in existing residential buildings was examined as a means to cope with global warming, and several barriers to improving the energy performance of existing dwellings instead of constructing new ones were explored. Systems adopted and implemented by developed European countries were considered and their feasibility was verified so that political measures could be suggested to improve the energy performance of existing dwellings in Korea.

A field survey on the systems used in developed European countries was carried out from February to March 2008, and interviews were conducted with researchers and personnel who were responsible for implementing political measures.

National authorities researched in this study are as follows.

- France: Ministry of Public Works, Transport, Housing, Tourism and the Sea (Ministère de l'Equipement, des Transports, du Logement, du Tourisme et de la Mer), Ministry of Employment, Social Cohesion and Housing (Ministère de L'emploi, de la Cohésion Sociale et du Logement), Direction Générale de L'urbanisme, de L'habitat et de la Construction (DGUHC).
- Germany: Federal Ministry of Transport, Building and Urban Development (BMVBS), German Government-Owned Development Bank (KfW), Institute for Preservation and Modernization of Buildings (IEMB), Federal Office for Building and Regional Planning (BBR), Energy Agency (DENA).
- Netherlands: Ministry of Housing, Spatial Planning and the Environment (VROM), TU Delft.
- Denmark: Danish Building Research Institute (SBI), Secretariat of Urban Regeneration, DTU.

2. Importance of existing residential buildings in coping with global warming

The importance of existing residential buildings in reducing greenhouse gas emissions can be considered quantitatively and economically.

Unlike other industrial products, new buildings account for a small fraction of the total housing stock. As shown in Fig. 1, in developed European countries, newly constructed buildings represent a small share of 1–1.5% in the housing stock, which is different from the situation in Korea. From a quantitative point of view, policies for new buildings, even though they are highly effective, have little influence because the number of new buildings in the overall building stock is small.

In Korea, newly constructed buildings represent a larger share compared to the other developed nations, and dwellings built after 1980 account for about 88% of the entire housing stock, which means they are in a relatively early stage of their lifespan (Fig. 2).

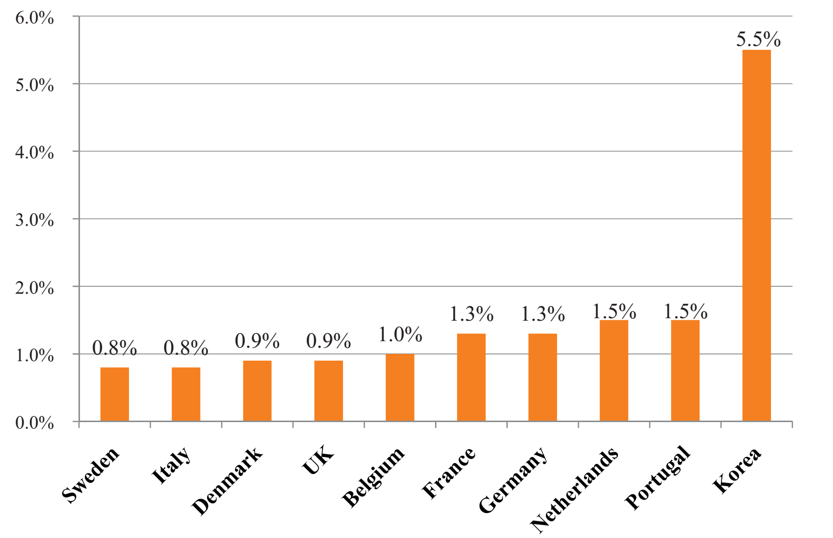
However, the housing construction policies that have satisfied quantitative demands are expected to come to an end in the coming years in Korea based on the following views: (1) the future economy and possibilities of resource consumption; (2) the fact that most existing houses were constructed after 1980 and so meet the occupants' demands to some extent; and (3) the other fact that the rate of housing supply across the nation has reached 108%. Thus, reconstruction work of houses, which has previously been frequent in Korea, will decline as will the influence of new construction on countermeasures against global warming, which has been the case in the developed European nations.

If a national scheme is to be set up in the future to reduce greenhouse gas emissions, policies focusing on new buildings will have limited effects, whereas political measures to improve the energy performance of existing dwellings will be of significance. Economic aspects are also significant in discussing the importance of existing dwellings. Measures that involve less cost and afford the same level of reduction in greenhouse gas emissions are economically efficient.

When the insulation of an existing house is refurbished, the cost of removing finishing materials, which are not necessary in the construction of new buildings, is required to be determined. Therefore, if new buildings and existing houses require construction or renovation work of the same type, it is reasonable to set the new buildings as a political target provided that the goal of greenhouse gas emission reduction is relatively low and there is no significant difference between them in emission reduction effects [9].

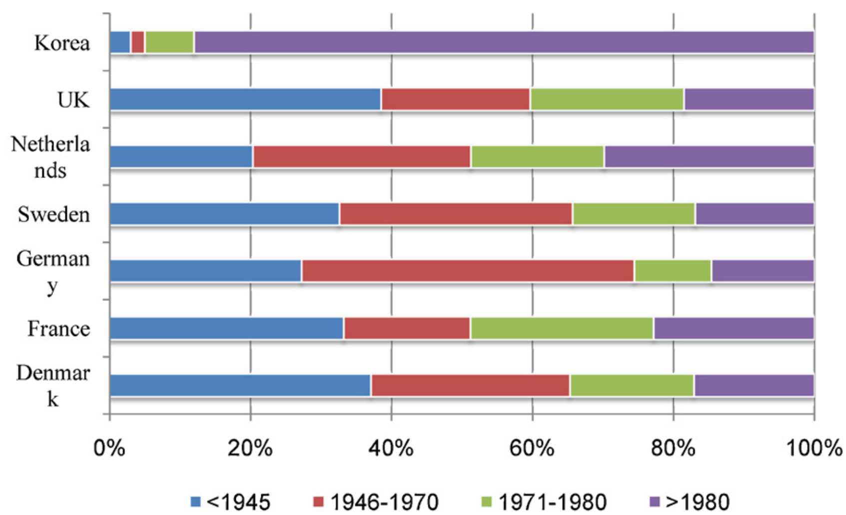
However, all industrial sectors, including the construction sector, will be forced to set their greenhouse gas emissions reduction targets as high as possible to cope with the enormous effects of the post-Kyoto regime on the economic development of Korea.

In addition, the effect of greenhouse gas emission reduction compared to investment costs is much higher in the existing residential building sector [5,10]. Thanks to technological progress and ever stricter regulations for energy designs, generally, new buildings have higher energy efficiency than existing buildings. Fig. 3 shows the yearly consumption of heating energy in the residential buildings in Denmark. The energy efficiencies of newly constructed houses are around thrice that of existing dwellings. The effects of energy efficiency renovation compared to costs are generally low in houses with high energy performance. Pezzey [11] performed a cost–benefit analysis of roof insulation in the UK; they determined the decrease in energy cost per unit investment cost by adding a 100-mm-thick roof insulation layer. When compared with the



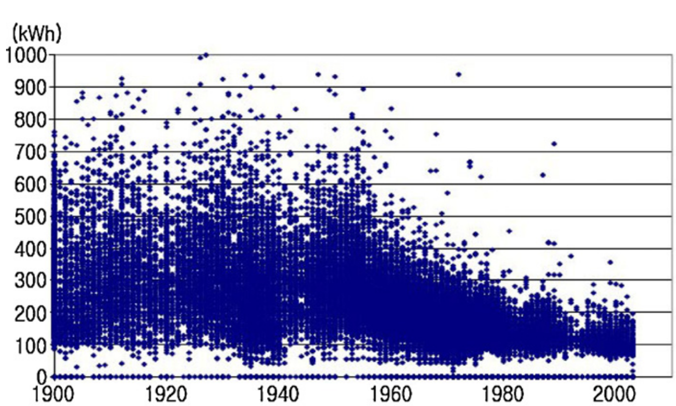
Source:Europe: Housing Statistics in the European Union 2004; Korea: The Ministry of Land, Transport and Maritime Affairs (for Europe, the average values of 1980 to 2003; for Korea, the average values of 1990 to 2005)

Fig. 1. Proportion of newly constructed dwellings in the total housing stock.



Source:Europe: Housing Statistics in the European Union 2004;Korea: 2005 Population & Housing Census(as for the data of Korea, <1959, 1960-1970, 1971-1980, >1980)

Fig. 2. Classification of houses per construction time.



Source: SBI

Fig. 3. Heating energy consumption of residential buildings in Denmark per construction year.

baseline case, i.e., no insulator, the effects were less than 30% for houses that originally had a 25-mm-thick insulator layer and less than 10% for those that originally had a 100-mm-thick insulator layer.

When the effects of energy efficiency improvements are considered compared to the costs, the gap between the cost of improving the energy efficiency of new and existing dwellings becomes wider if there is a larger difference in initial energy performances of the new and existing dwellings. This implies that a strategy to reduce greenhouse gas emissions targeting new buildings with high energy efficiency would cost more.

Martin [12] analyzed the energy renovation of the residential building stock in Switzerland. He concluded that building renovation in particular but also the construction of new buildings offers a large energy reduction potential with comparatively low or even negative marginal costs. Another Swiss study [13] found that there are two relevant factors in the economic assessment of energy renovation: energy price and a supportive financial energy policy. They

Table 1
Renovation expenses of homeowners with different incomes.

Income	Rate of home ownership (%)	Renovation expense a week	Ratio of renovation expense to total income
Below £100 a week	5	4.72	6.3
£100–174 a week	11	5.18	3.8
£175–274 a week	15	6.73	3.0
£275–474 a week	33	8.86	2.4
Above £475 a week	37	14.44	2.1

Source: UK Central Statistical Office (1992).

found that it would be economically wrong to renovate a house without a simultaneous investment in energy efficiency because this is a highly attractive investment for homeowners or other investors.

Thus, to attain national goals, the existing residential building sector should be set as a political target as this is more economically efficient for reducing greenhouse gas emissions than focusing on new buildings.

3. Barriers to energy efficiency improvement in existing residential buildings

As mentioned above, improving the energy efficiency of existing buildings has great potential for mitigating the effects of global warming, but it is more difficult to improve the energy efficiency than that of new ones. To meet the goal of enhancing energy efficiency, it is necessary to identify these difficulties.

3.1. Lack of awareness of energy performance

One issue with improving energy efficiency is that its effects are difficult to recognize. Even if an energy-related renovation is carried out on a house, its effects are sometimes hardly felt if there is rise in energy prices or the life pattern of the occupant changes (e.g., raising the set temperature of a heating installation). Even in cases where house maintenance expenses such as lighting and heating costs are reduced due to renovation, the amount of cost reduction is generally far less than the investment costs, and the payback period is too long. Thus, there is little active investment activity to improve energy performance.

Another issue regarding the lack of awareness is that a house's energy performance is seen as unimportant in terms of investment value. The energy performance of an existing house is often not considered relative to its exterior when sold or rented out [14]. Even if the asset value of a dwelling is raised by improving its energy performance, it is not easy to demonstrate such a value increase to the prospective buyer or tenant. In other words, a house's energy performance has little effect on its market price.

Therefore, people's lack of awareness of the energy performance is a barrier to motivating them to participate in improving the energy efficiency of dwellings.

3.2. Financial reasons

Financial difficulties are often stated as a barrier to improving energy efficiency in buildings [5,10].

Enormous costs are required to improve the energy performance of existing dwellings to the level of new buildings, and the investment costs of housing renovation are a great burden, especially to low-income families. As shown in Table 1, which presents the expenses of housing renovation in the UK, the total incomes of families are inversely proportional to the housing renovation expenses. In the highest income class, the expense of renovation is high but represents merely 2.1% of the total income, while in the lowest income families, the expense of renovation is just a third of that of the highest income class but accounts for 6.3% of the total income; this makes the burden of renovation too heavy to their household finances. On the other hand, the houses of low-income families often have low energy performance, so improvement in the energy performance is likely to have notable effects.

Such an imbalance between houses with great potential for CO_2 reduction and the incomes of the occupants is a significant barrier to improving the energy performance of existing residential buildings.

3.3. Insufficient information

When a new building is constructed, its owner, constructor, architect, real estate broker, and other professionals can have regular meetings on work that influences the energy efficiency of the building, whereas the owner of an existing dwelling has few chances to meet with those professionals and so rarely obtains relevant information.

According to a survey on the state of housing demands by the Ministry of Land, Infrastructure, Transport, and Tourism of Japan, the greatest difficulty with renovation work other than a lack of money is "insufficient information" (23.7%) [15]. Even when a housing renovation is considered, there are few advice agencies on renovation methods, and information on constructors is limited. This situation of insufficient information is a major barrier to energy renovation of existing dwellings.

3.4. Absence of regulatory systems

The construction of new buildings is regulated under complete legal frames even before the construction is planned, whereas there is no extensive regulatory system to cover the existing residential building sector. Thus, high administrative costs are expected to be necessary when a new regulatory system is introduced for existing dwellings. In addition, the existing dwellings, even though they are inconsistent with current energy standards, were permitted legally at the time of construction. It is difficult to reach an agreement between the parties of interest if new stricter regulations are applied retroactively to existing residential buildings. For these reasons, existing dwellings with poor energy performance are often left as they are without any renovation efforts.

4. Policies of developed European countries on improvement of energy performance of existing dwellings

Here, research on the policies of developed European countries is mainly about how the policies have responded to the barriers provided in Section 3 and how much they have contributed to improving energy performance of existing residential buildings.

4.1. Building energy performance certification system of EPBD

The European Commission (EC) promulgated the Energy Performance of Buildings Directive (EPBD) in January 2003 [16]. The European Union (EU) predicted that the EPBD would contribute to reducing the energy consumption of buildings in Europe by 10% by 2010 and by 20% by 2020 while helping give energy performance certificates to two million residential buildings and decrease CO_2 emissions by up to 45 million tons by 2010 [17].

Since 2006, all EU members have implemented a certification system under the EPBD to extensively assess the energy performance of buildings, including CO_2 emission indicators. The energy performance certification system for buildings measures and indicates the energy performance of a building in a similar manner to the certification system for electronic appliances. The system basically targets new buildings, but when a building is offered for sale

or rent, the owner has the obligation to display an energy certificate of the building. The validity of the certificate does not exceed 10 years.

The goals of the certification system are to offer information on the energy performance of buildings to prospective buyers or tenants, to ensure the transparency of real estate transactions, and to add items of energy performance to the consumers' criteria for selecting dwellings so that the building owners would be encouraged to conduct renovations to save energy.

Even though assessments of the energy performance of buildings can vary in methods and/or types of certificates according to region, the EPBD requires that the assessment should include energy labeling and reference values under current legal standards so that consumers can compare the energy performances of different buildings; in addition, the certificate should include recommendations for cost-efficient improvements to the energy performance [16,18].

Before formally introducing the EFBD energy performance certification system, Germany implemented the system on a yearlong trial basis in 2004 and conducted a survey on the effectiveness of the system. For the survey, 33 cities, 31 housing firms and representatives of local residents, six local electric power companies, and the energy agencies of seven regions were selected and asked about the costs of the energy performance assessments and energy performance certification. In the survey results [19,20], 58% answered that they were able to realize the need to improve energy performance by objectively assessing the performance of their own houses, and about 30% answered that the energy performance certification led to energy renovations. More than 90% of those surveyed replied that they think the EPBD would affect the values of residential buildings on the market.

A study by ECOFYS [21] reported that implementing the EPBD had the effect of reducing costs by about €4 billion every year until 2010; furthermore, if the scope of the EPBD is extended from houses with a total floor area of more than 1000 m^2 to all residential buildings, up to €7.5 billion will be saved every year.

These results imply that an energy performance certification system for buildings has positive effects on overcoming the barrier of "little intension of conducting renovations for energy efficiency of buildings owing to lack of awareness," as mentioned in Section 3.

4.2. Financial support for improving energy efficiency

In France, a subsidy of not more than 20% of the construction costs (upper limit: €11,000) is granted for general renovations of private dwellings, and grants as well as subsidies are given for renovations to improve energy performance. The grants are as follows [22]:

- A renovation of windows and doors to confirm with standards for high energy efficiency: €800.
- A condensing boiler that conforms to standards: €900.
- A heating system that consumes new renewable energy: €1800.

For installation of new renewable energy equipment, the tax credit has been increased from 15% to 40% of the expenses, and for high-efficiency insulators, a tax credit of 25% of the investment cost is provided [23].

The financial support provided by France to improve the energy performance of buildings is characterized by subsidies that vary according to income levels, so the poor are granted subsidies preferentially. Globally, government expenditures have been reduced on the waves of neo-liberalism. With limited financial resources, giving priority to low-income classes can play a part in solving the difficulty stated in Section 3.2: "imbalance between houses with a great potential for CO_2 reduction and the incomes of the occupants." In addition, targeting low-income families will help obtain public and political support.

	Direct subside	Loan
KfW Efficiency House 55	17.5% subside Max. EUR 13,125	100% loan, Max EUR 75,000 12.5% Repayment grant
KfW Efficiency House 70	15% subside Max. EUR 11,250	100% loan, Max EUR 75,000 10% Repayment grant
KfW Efficiency House 85	12.5% subside Max. EUR 9,375	100% loan, Max EUR 75,000 7.5% Repayment grant
KfW Efficiency House 100	10% subside Max. EUR 7,500	100% loan, Max EUR 75,000 5% Repayment grant
KfW Efficiency House 115	7.5% subside Max. EUR 5,625	100% loan, Max EUR 75,000 2.5% Repayment grant
Individual measure	5% subside Max. EUR 2,500	100% loan, Max EUR 5,000

Fig. 4. KfW energy-efficient renovation program.

Another characteristic of the financial support of France is that the support is provided for both general housing renovations and energy renovations. Such an integrated approach allows people to have more opportunities to improve the energy performance of houses since renovations are sometimes to enhance the material quality of a house and not to improve its energy performance; however, even in that case, windows or old installations are often replaced.

Government programs aimed at promoting energy savings in housing have been in place in Germany since the 1970s. The KfW, which is the investment bank of the federal and regional governments, is the main source of funding for investment in energy efficiency and renewable energy rather than the federal government itself. The government negotiates conditions with the KfW, including access to assistance, the amount of loan funding available, and the level of subsidies to reduce interest rates on loans [24]. The KfW energy-efficient renovation program for residential buildings offers long-term, low-interest loans for renovation projects aimed at reducing energy consumption. The program also offers direct subsidies for investment costs. Repayment grants are provided if the renovated housing meets KfW efficiency house standards, which set limits based on energy consumption and heat loss permitted for new buildings under the Energy Conservation Ordinance (Energiesparverordnug/EnEV).

Subsidies are supported in a variety of ways depending on the degree of improvement in energy efficiency (Fig. 4). KfW has defined five levels of support for a "KfW efficiency house." Simply put, the figures indicate the percentage of the maximum primary energy requirements as specified by the EnEV that the house consumes. The best standard (KfW efficiency house 55) receives the highest support. To meet the high energy standards of a KfW efficiency house, extensive investments such as the renewal of heating systems, thermal insulation, and window replacement are usually required.

As mentioned above, Germany operates support programs that vary according to the types of renovations to improve the building energy performance and provide more favorable benefits to older houses being renovated. Those efforts have made it possible

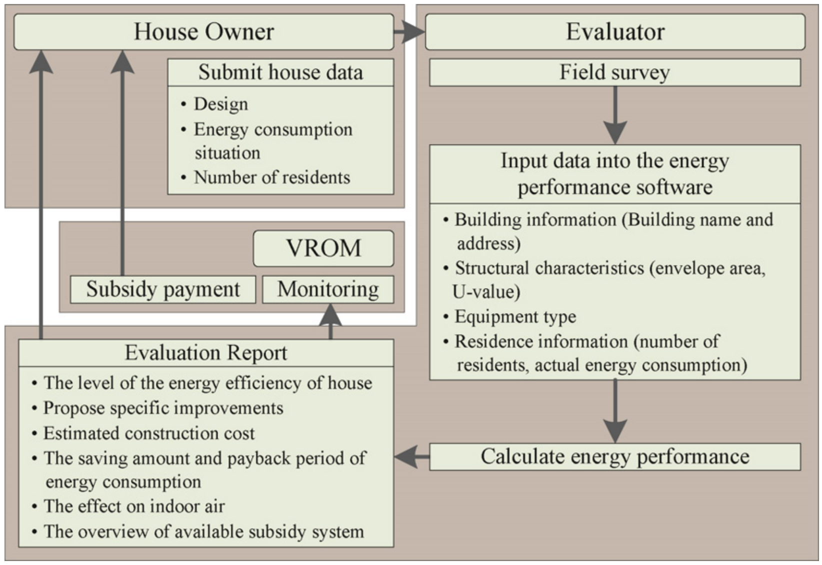


Fig. 5. Process of Energy Performance Advice (EPA).

to promote renovations to improve the energy efficiency of existing residential buildings.

France takes an integrated approach to cover both general renovations and renovations to improve energy performance, while Germany takes an intensive approach with the aim of improving energy performance. Germany's advantage has the advantage that policies can be set so that intensive support and management is provided, especially to where buildings are in great need of energy performance improvement, although it cannot give additional opportunities to improve energy performance. These two types of support need to be examined in terms of political cost relative to efficiency. For Korea, where recently built dwellings represent a large share of the whole housing stock, Germany's intensive approach is regarded as more effective since the recently built buildings satisfy to some extent the standards for physical qualities of buildings and there is rising concern about global warming.

4.3. Supply of information on building energy performance

To achieve the greenhouse gas emission reduction goals set by the Kyoto Protocol, the Netherlands aimed to reduce their CO_2 emissions of 5.5 million tons in the building sector every year by 2010.

The Dutch government has focused on the potential for energy efficiency improvement in existing buildings, and the Energy Performance Advice (EPA) program is at the center of the government's policies. The EPA provides relevant information: for example, it supplies data in a prescribed form on the effects of energy efficiency renovations to homeowners.

The EPA was introduced in 2000 and has targeted existing residential buildings constructed before 1998. It operates according to the process shown in Fig. 5.

A homeowner who wants to assess the energy performance of his or her house writes down the information of the house in a prescribed form and submits it to a qualified assessment expert.

The assessment expert conducts a field survey to collect additional information on the building designs, life patterns of the occupant (e.g., pattern of energy use), and so on. With the collected information, the expert calculates the energy performance of the building with a designated software program and draws up an assessment report. The report includes the level of energy efficiency of the building, concrete recommendations for energy renovations, estimated costs for the required renovations, the predicted amount of reduction in energy consumption, the payback period, an overview of support programs available, and so forth.

The assessment results are sent to the owner, who decides if the recommended renovations shall be conducted or not. If the owner carries out any of the recommended measures, a grant of €200 is provided by the government as the cost for the assessment application. A certification system for assessment experts began in July 2002. Since then, government support is only granted if a qualified assessment expert draws up a report. When a recommended measure of the EPA is carried out by linking to the Energy Premium (EPR) scheme, which grants subsidies for energy savings, the subsidy is increased by 25% compared to general grants. The assessment expert submits the assessment report to the Ministry of Housing, Spatial Planning and the Environment of the Netherlands (VROM), which uses those reports for activities such as monitoring the energy performance of existing residential buildings.

The EPA is similar to the energy performance certification system of the EPBD in that the former provides owners with information on investment costs and economic profits, including the estimated renovation costs and energy costs. Thus, the assessment experts and building energy performance assessment tool of the EPA have been used to implement the EPBD.

However, the energy performance certification system is compulsory for buildings that are to undergo major renovations or to be offered for sale or rent in order to change the way people perceive the energy performance of dwellings, whereas the EPA is a voluntary system to be implemented by the homeowner's request and its primary function is to provide information. The EPA has been used extensively since its introduction. Through the EPA program, assessment reports were initially issued for 17,000 dwellings in 2000 and for more than 10% (about 6.8 million dwellings) of the total housing stock by 2006 (Fig. 6).

In order to evaluate the validity of the EPA program, it was operated on a trial basis before its formal introduction from 1999 to 2000. The results of the trial operation showed that the average energy saved by residential buildings was 30% if the recommended renovations in the assessment reports were carried out fully. The average investment cost for the recommended renovations was €910, and the estimated yearly energy saving was equivalent to €182, so the payback period was about five years. Since the data

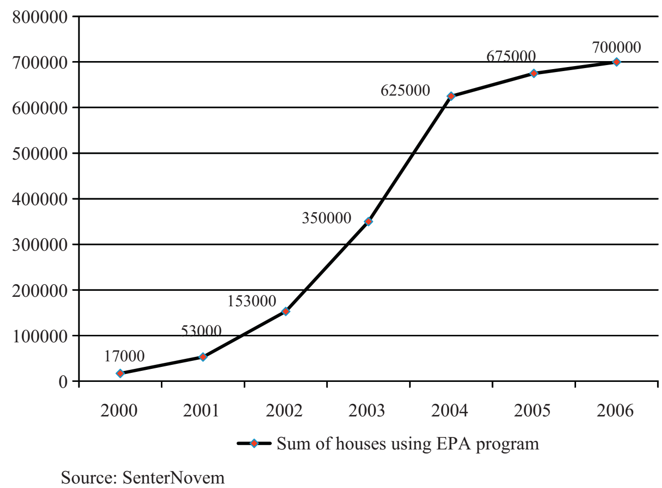


Fig. 6. Sum of houses that have used EPA.

on the renovation potential are offered to building owners who previously had difficulty accessing such information on energy performance, the program can be regarded as effective in promoting improvements to the energy performance of existing residential buildings.

In addition to the budget for the subsidy of €200 as the cost for assessment report preparation and the funds for renovations, €15.88 million were secured for the period of 1999–2003; these funds were used to cover the costs of developing software programs to assess the energy performance of buildings, run training programs for assessment experts, and pay other costs relevant to the system. Since these administrative costs were used to establish the framework of the system, much less funds have been required for the system to operate since then. Specifically, only the costs for upgrading software programs and monitoring the system have been required excepting the cost for assessment report preparation; this has been estimated to be €15 per dwelling unit.

4.4. Building regulations on energy performance of existing residential buildings

The minimum requirements for the energy performance of existing residential buildings as stipulated in the building regulations of most countries generally apply to existing buildings undergoing major renovations. However, several countries currently enforce regulations on energy performance over existing residential buildings in order to attain their goals set according to the Kyoto Protocol [25,26]. This section briefly summarizes the regulations on energy performance of existing residential buildings in the target countries of this study and presents details of such regulations in Germany, which is the strictest in regulating the energy performance of buildings.

France enforces a regular inspection every three years for boilers with a capacity of more than 300 kW. The Netherlands stipulates that a regular inspection be carried out every year and that boilers with a capacity exceeding 100 kW conform to the current energy performance standards as provided in the Law of the Environment. The regulations of Denmark require a regular inspection to be conducted every year for all boilers in dwellings but have no provisions for the replacement of installations. In addition, the renovation of roofs, renovation of the insulation of exterior walls, replacement of windows, installation of a boiler, and replacement of a heating installation should be in accordance with current Danish standards regardless of the building size. The Heat Supply Act (Lov om varmeforsyning) was revised to substitute the electric heating of existing buildings with other energy sources. According to the act, electric heating is prohibited for houses in a network of district or natural gas heating. The revised act came into force in January 1994. It was predicted that thanks to the revision, dwellings with electric heating would decrease by up to 7000 units by 2005.

The existing residential buildings were constructed in accordance with the regulations at the time, so forcing them to undergo structural renovations to bring their energy performance up to the level of new buildings is demanding. Such renovations require substantial time and cost. Most countries thus target installations that are simple to replace instead of renovations of structural elements. Germany has implemented similar measures but has applied stricter regulations to existing dwellings compared to other European nations.

In Germany, complete replacement of heating and hot water supply systems needs to conform to the energy standards in force. When structural elements of a building are replaced to improve energy efficiency for cooling or heating the space, each of the structural elements should conform to the prescribed standards (*U*-value), or energy consumption by the building as a whole should not exceed 140% of the level of new buildings. Significant replacements of windows, doors, and/or exterior walls that make up more than 20% of the whole building should be in accordance with the standards for new buildings. Replacing boilers installed before 1978 with those conforming with the current standards by December 31, 2006 was compulsory. By December 31, 2006, German regulations specified that heating and hot water pipes for spaces with no heating installation should have been insulated and spaces with heating installation should satisfy a *U*-value of at least 0.3 W/m^2 K.

The German federal government expanded and revised the CO_2 building rehabilitation program at the end of 2005 with the aim of mitigating the resistance arising due to forceful measures to specify improvement dates for old installations with high environmental loads and to promote renovations to improve the energy performance of dwellings. While implementing the program, the government has offered active support in replacing installations under its control.

The Ministry of Transport, Building and Urban Development of Germany (BMVBS) reported that in 2006, the loans for energy performance improvement amounted to €3.4 billion, and 230 thousand dwelling units conducted renovations with low-interest loans [27]. The ministry regarded these series of measures as successful, saying that the number of houses that were renovated in 2006 with the KfW programs to improve the energy performance was more than three times the number of 2005.

Applying regulatory measures to existing buildings can be influenced by the absence of relevant provisions in the previous regulations and resistance from the public. To identify factors with high environmental loads or to check if minimum requirements are met, the researched countries organized their systems, including field surveys, and set a limited scope of houses as the target for improvement. The energy used for heating or hot water supply accounts for more than 80% of the total energy consumption by the residential building sector of Europe, so the building regulations on energy performance of the European countries focused on heating and hot water supply installations that are worn out and thus cause significant environmental loads.

After analyzing the building regulations on energy performance of existing residential buildings, it is necessary to organize systems to assess the energy performance of existing residential buildings in order to determine factors with high environmental loads and which of these factors are easy to replace or improve as regulation targets. In addition, it is possible to introduce subsidies or other incentives to minimize the resistance of the people concerned.

5. Conclusion

As mentioned in Section 2, the building sector is under strong pressure to reduce greenhouse gas emissions, and existing residential buildings are expected to play an important role in enabling countries to achieve their goals of reducing greenhouse gas emissions. However, improving the existing buildings as a means to reduce greenhouse gas emissions is more difficult than improving the energy efficiency of new buildings, as discussed in Section 3. To design a policy that targets the existing residential building sector, much attention needs to be paid to the possible effects of the various components of the policy. Section 4 presents the cases of four European countries that have executed political measures for existing dwellings. The experiences of the four aforementioned countries revealed the following, including methods for overcoming the barriers that hinder enhancements to the energy efficiency of existing residential buildings.

(1) Based on the survey of the results and effects of the trial operation of the EPBD building energy performance certification system, the system has changed people's awareness of energy performance and enabled energy efficiency to have noticeable effects on house prices in the market. Even though an energy efficiency certification system for buildings has been implemented in Korea, the results are still insignificant because the system is applied only when there is a voluntary request from a dwelling with more than 18 families. As of June 2006, among 815 buildings with an energy consumption of more than 2000 TOE a year, only 69 buildings have made a voluntary agreement with the Korea Energy Management Corporation. Such buildings represent a mere 8.4% of the total target buildings. The government is reviewing measures to enforce the energy efficiency certification system for new buildings that are larger than a certain size so as to raise the effectiveness of the system. However, it is necessary to review methods to force existing buildings to be assessed with the certification system when they are sold or rented out because there is greater potential to reduce the greenhouse gas emissions by improving existing residential buildings than constructing new ones. Unlike European countries, multi-family dwellings account for a large share of the total housing stock in Korea, so issuing certificates to each and every family is demanding. A possible solution to the difficulty is a phased method by which the oldest multi-family dwellings are forced to be assessed by the building energy efficiency certification system first, and after a certain period, their certificates are renewed.

Because assessing the energy performance of existing residential buildings is more difficult than assessing that of new ones, it is cost-efficient for experts to survey each building site and provide the owners with the relevant information. Organizing a system to upgrade the assessment quality of the experts is therefore an important task.

(2) To provide financial support for energy renovation, France takes an integrated approach to cover both general renovations and renovations to improve energy performance, whereas Germany takes an intensive approach with the aim of improving energy performance. The German approach has the advantage that policies can be set so that intensive support and management is provided, especially to buildings in dire need of energy performance improvement, although it cannot give additional opportunities to improve energy performance. These two types of supports need to be examined in terms of political costs to efficiency. In Korea, where recently built dwellings represent a large share of the total housing stock, an intensive approach such as that of Germany is regarded as more effective because recent buildings satisfy to some extent the standards on the physical qualities of buildings, and there is rising concern about global warming. Similar to France, it is also possible to give priority to buildings of low-income classes, for which renovations are highly efficient compared to costs, to obtain maximum results with limited financial resources.

(3) The EPA of the Netherlands is a system by which a qualified assessment expert conducts a field survey at the request of a homeowner and provides the owner with information on how to improve a home's energy efficiency, including the method and cost of renovation, estimated energy cost, economic profit, and cost of investment. The EPA has great potential for assessing the validity of renovation.

The EPA is similar to the energy performance certification system of the EPBD in some ways. If the building energy efficiency certification system of Korea becomes compulsory in the future for existing residential buildings as well, the system can be linked with an EPA-like program to provide energy renovation-related information to homeowners who want it. This linking will make it possible to promote investments without adding administrative costs to the government's burden. In addition, it should be more effective to provide integrated information on renovations to builders, even though such information is not provided by the EPA program.

(4) The regulations on the energy performance of existing residential buildings have remarkable effects on reducing the greenhouse gas emissions but have been difficult to apply due to reasons such as the resistance of homeowners. Most countries have carried out measures to identify factors with high environmental loads and regulated some of the factors that are simple to replace or renovate. If such regulations are to be implemented in Korea, factors that have a great potential for reduction and a minimum scope of application need to be specified and reviewed. It is also necessary to organize related systems to identify regulation targets.

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